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Morphological Study of the Carpal Tunnel and the Ulnar Canal

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Summary

Ten adult upper limbs after the injection of the resin were cut into 5 mm cross-sections.

The morphology of the wrist joint, especially of the carpal tunnel and the ulnar (Guyon) canal was examined under the stereoscopic microscope.

The carpal tunnel departs from the palm gradually, from the inlet to the outlet, and the thickness of the flexor retinaculum increases and becomes maximum at the outlet.

The flexor retinaculum, for surgical treatment of the carpal tunnel syndrome, must be released completely to its distal part to secure complete release of the median nerve.

Since the ulnar canal itself has few bone elements, no tight connective tissue on the palmar side except for the inlet portion, and no tendons passing through it, chronic mechanical irritation is unlikely occur without chronic external trauma or mechanical narrowing such as by a tumor or a fracture fragment.

Introduction

Peripheral nerves pass through tunnels (entrapment points) formed by the fascia, tendon sheath, ligaments, and bone sulci as they run distally. Therefore, narrowing of these tunnels for any reason may cause constriction of the nerves. Persisting mechanical irritation such as that due to joint motion induces so-called friction neuritis, and progression of connective tissue proliferation in and around of the nerve trunk results in irreversible fibrosis. If nerve fibers become constricted the axonal flow distal to the entrapment point is gradually impaired, causing axonocachexia and, eventually, Wallerian degeneration.

Entrapment neuropathy is considered to be caused primarily by 1) mechanical compression of the local nerve trunk, 2) friction fibrosis secondary to chronic mechanical irritation, and 3) anoxia due to circulation insufficiency in and around the nerve trunk.

In entrapment neuropaty, unlike simple compression neuropathy, fibrosis in the nerve trunk

Key words: Entrapment neuropathy, Carpal tunnel syndrome, Ulnar (Guyon) canal syndrome, Median nerve, Ulnar nerve.
索引語：絞扼性神経障害，手根管症候群，尺骨管症候群，正中神経，尺骨神経.
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induced by chronic mechanical irritation, especially friction, is one of the most important causative factor.

The authors prepared the serial cross-sections, around the wrist joint at 5 mm intervals, and examined the morphology of the carpal tunnel and ulnar (Guyon) canal under the stereoscopic microscope.

Tissue sections 50 μm in thickness were also prepared under the light microscope.

Methods

Using TANIGUCHI-OHTA's resin injection method acrylated resin was injected into brachial artery from axillary region.

Ten adult upper limbs were cut into 5 mm cross-sections perpendicular to the axis using BS-3000 (EXAKT, West Germany).

The morphology of the wrist joint, especially of the carpal tunnel and the ulnar canal was examined under the stereoscopic microscope.

Fig. 1 shows the slice levels.

Tissue sections 50 μm in thickness stained with hematoxylin-eosin were also prepared and studied under the light microscope.

Results

In the slice containing the proximal portion of the lunate, neither the carpal tunnel nor the

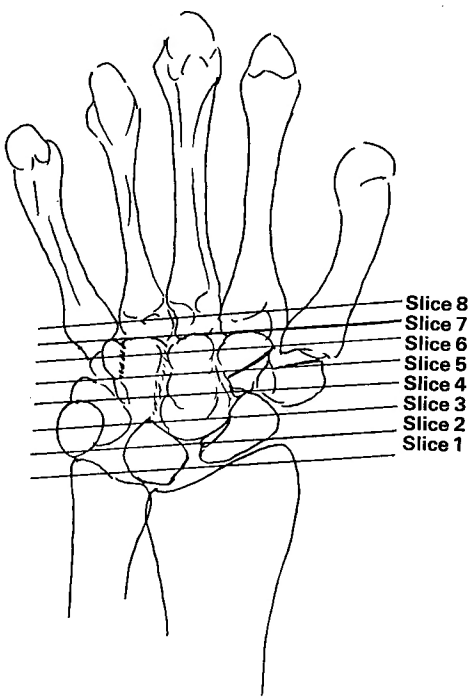

Fig. 1. Slice levels of each section are shown.

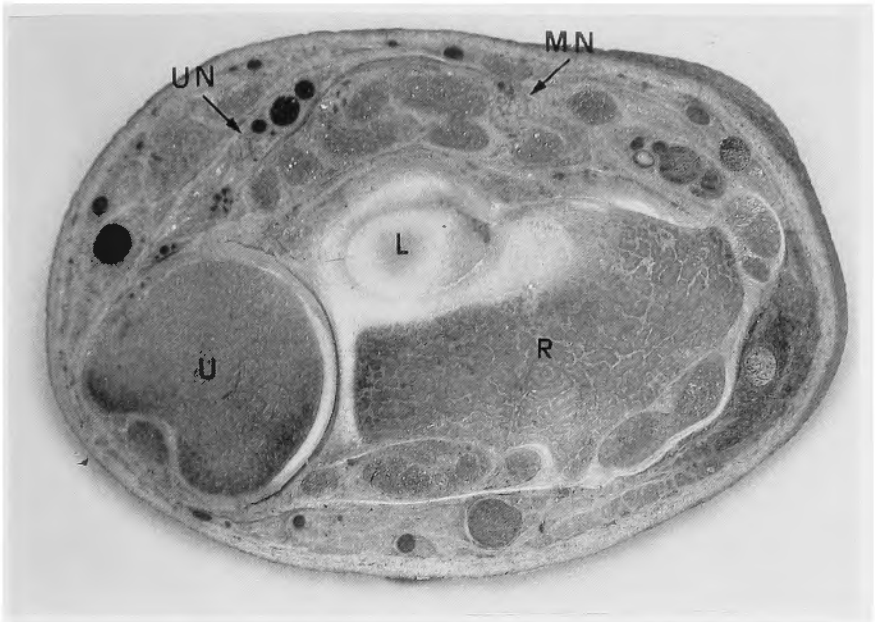

Fig. 2. In slice 1, at the proximal portion of the lunate, there was no obvious tunnel formation. UN : ulnar nerve, MN : median nerve, U : ulna, R : radius, L . lunate.

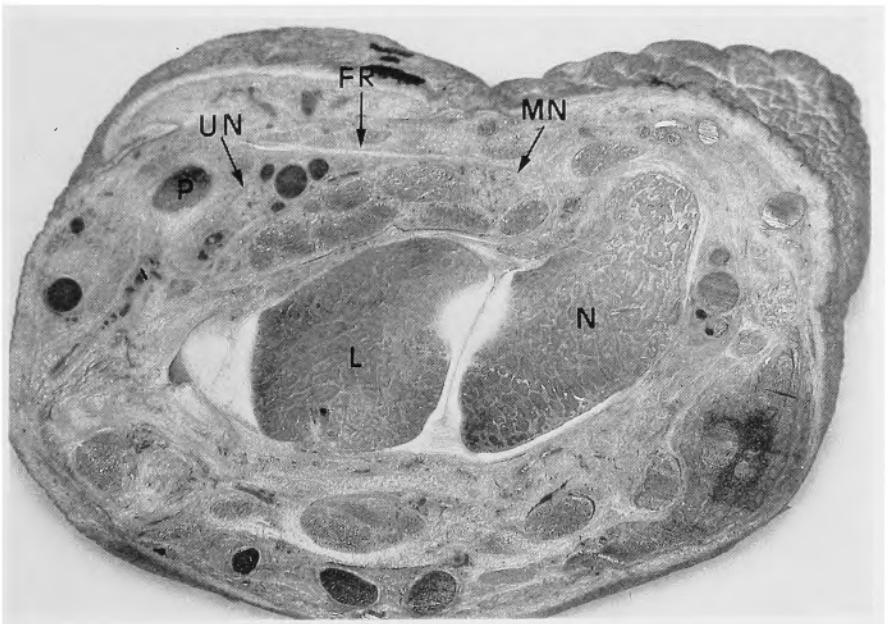

Fig. 3. At the inlet of carpal tunnel and ulnar canal (slice 2), flevor retinaculum became obvious. UN : ulnar nerve, MN : median nerve, L : lunate, FR : flexor retinaculum, P : pisiform, N : navicular,

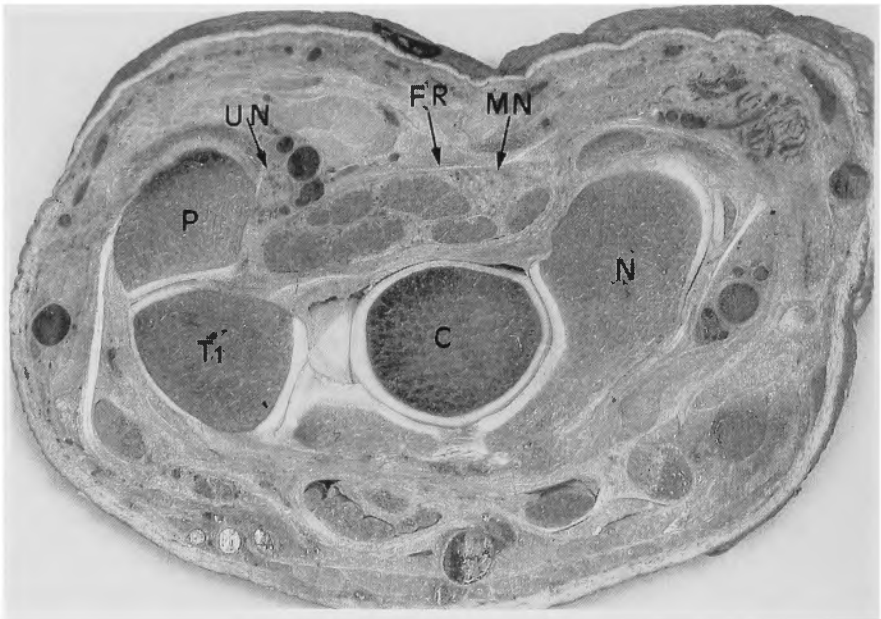

Fig. 4. Carpal tunnel and ulnar canal at the middle portion of pisiform and navicular (slice 3). P : pisiform, T1 : triquetrum, C : capitate, N : navicular, UN : ulnar nerve, MN : median nerve, FR : flexor retinaculum.

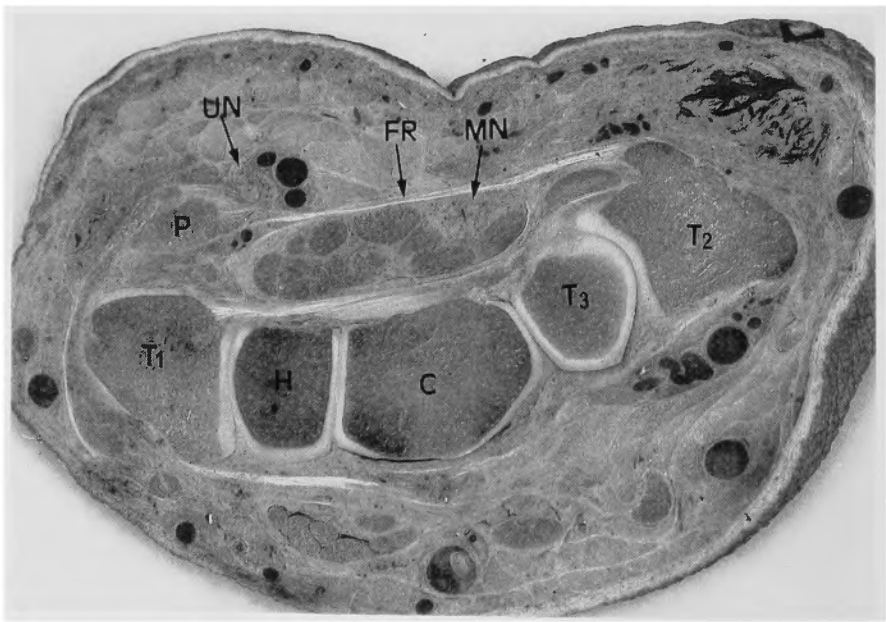

Fig. 5. At the distal portion of pisiform (slice 4), median nerve ran immediately dorsal to the flexor retinaculum. Hypothenar muscle was observed medially to the ulnar canal.
UN : ulnar canal, MN : median nerve, FR : flexor retinaculum, P : pisiform, T1 : triquetrum, H : hamate, C : capitate, T2 : trapezium, T3 : trapezoid.

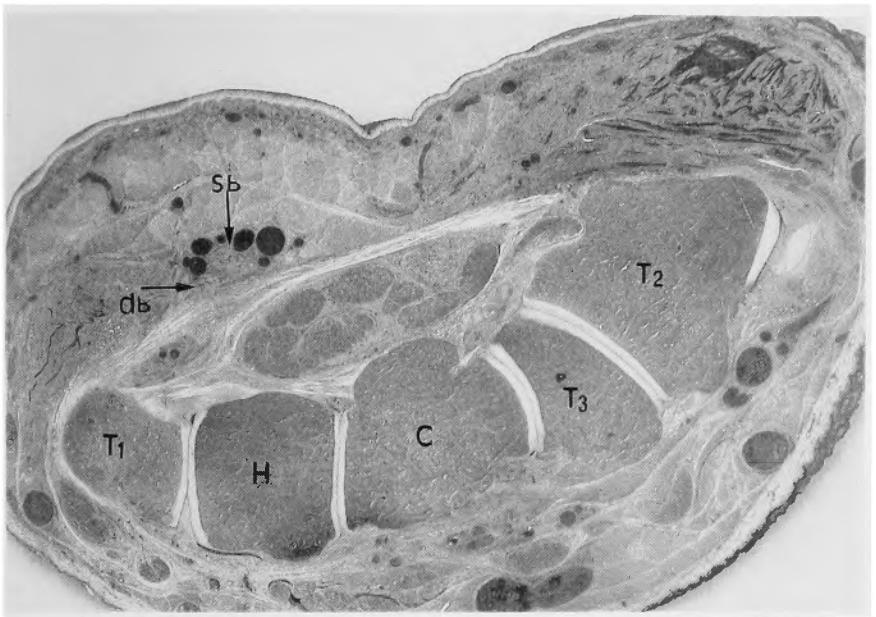

Fig. 6. At this level (Slice 5) ulnar nerve divided into superficial and deep branch in the ulnar canal. But no obvious septum was observed. Concomitant artery and vein of each branch of nerve were observed.

sb : superficial branch of ulnar nerve, db : deep branch of ulnar nerve, T1 : triquetrum, H : hamate, C : capitate, T3 : trapezoid, T2 : trapezium.

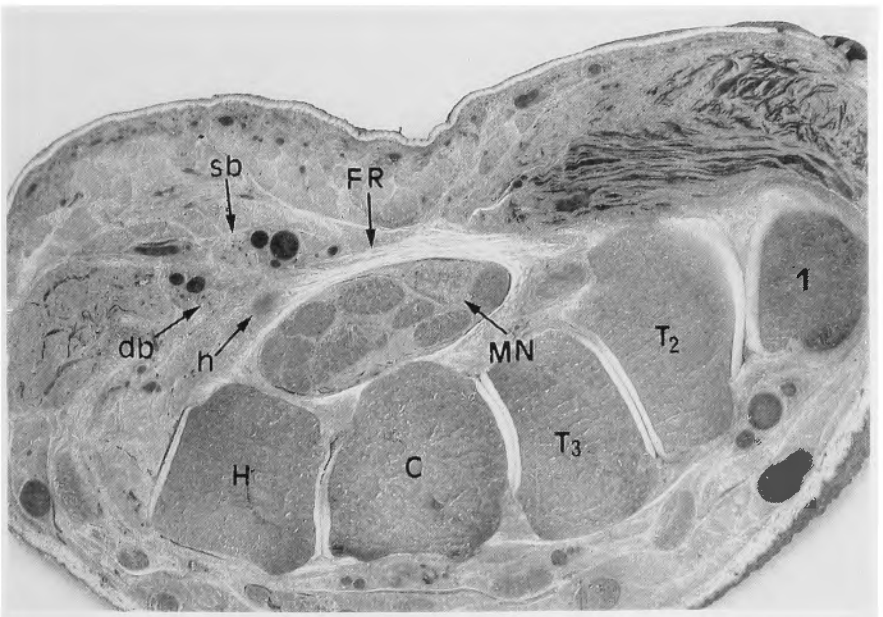

Fig. 7. At the level appearing hook of hamate (slice 6), flexor retinaculum became thicker. Piso-hamate ligament was observed between superficial and deep branches of ulnar nerve. Both branches accompanied their own artery and vein.

sb : superficial branch of ulnar nerve, db : deep branch of ulnar nerve, FR . flexor retinaculum, h : hook of hamate, MN : median nerve, H : hamate, C : capitate, T3 : trapezoid, T2 : trapezium, 1 : 1st metacarpal bone.

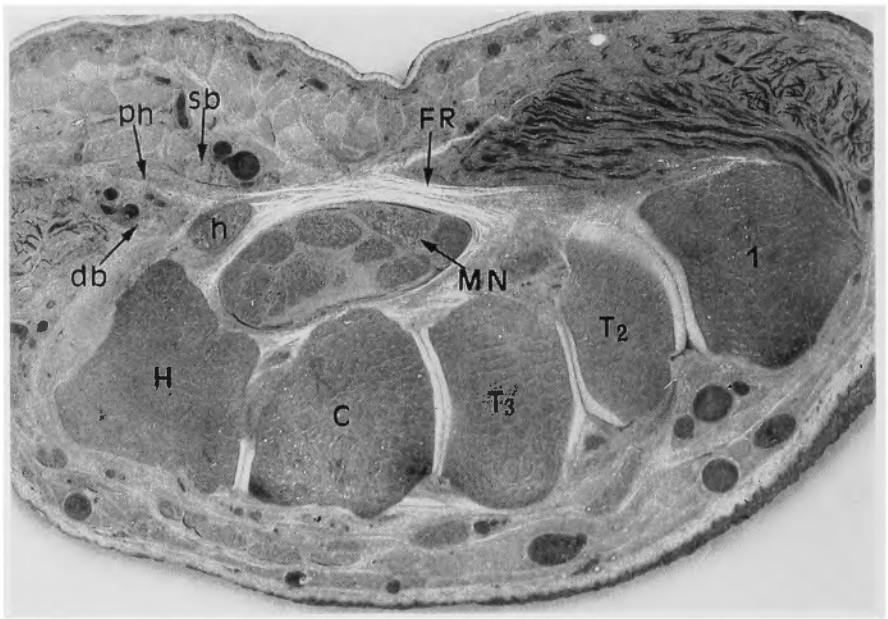

Fig. 8. At the level just proximal to the outlet of canals (slice 7), the thickness of the flexor retinaculum became maximum. Piso-hamate ligament became distinct.
ph : piso-hamate ligament, sb : superficial branch of ulnar nerve, db : deep branch of ulnar nerve, FR : flexor retinaculum, h : hook of hamate, MN . median nerve, h : hamate, C : capitate, 1 . 1st metacarpal bone, T3 : trapezoid, T2 : trapezium,

Fig. 9. At the level of proximal part of metacarpal bones (slice 8), flexor retinaculum disappeared. Recurrent branch of median nerve was observed. Superficial branch of ulnar nerve was observed with concommitant artery and vein.
sb : superficial branch of ulnar nerve, MN · median nerve, rn : recurrent branch of median nerve, 1-5 : 1st-5th metacarpal bone.

ulnar canal was observed (Fig. 1). At the inlet of the carpal tunnel and the ulnar canal, the median nerve ran with 9 tendons immediately dorsal the flexor retinaculum. At this level, the ulnar nerve ran with the ulnar artery and vein on the dorsal side of the flexor retinaculum. The carpal tunnel was separated from the ulnar canal by a thin septum (Fig. 3). In the slice passing the middle part of the pisiforms and the navicular, the flexor retinaculum became distant from the palm surface and was connected to the pisiform. The ulnar canal penetrated the flexor retinaculum to the palmar side. The palmar side of the ulnar canal was covered with fat tissue (Fig. 4). In the level of the proximal trapezium and the distal pisiform, the flexor retinaculum farther retreated from the palm surface and increased its thickness. The median nerve ran immediately dorsal the flexor retinaculum also at this level. The hypothenar muscle was observed medially to the ulnar canal, which was not surrounded by tight connective tissue except for the dorsal side (Fig. 5). In the slice containing the middle portion of the trapezium and the distal portion of the triquetrum, the flexor retinaculum was further thickened. The ulnar nerve divided into the superficial and deep branches, but no septum was observed between these branches. Each of them ran with a artery and a vein. No large artery was observed around the median nerve (Fig. 6).

In the slice containing the base of the 1st metacarpal bone and the hook of the hamate, the thickness of the flexor retinaculum was further increased, and the carpal tunnel became more distant from the palmar surface. The median nerve still ran immediately dorsal the flexor retinaculum. A septum, continuous with hamate (piso-hamate ligament) was observed between the superficial and deep branches of the ulnar nerve (Fig. 7).

At the outlets of the carpal tunnel and the ulnar canal, the flexor retinaculum showed a maximum thickness and connected the hook of the hamate with the trapezium. The median nerve progressively flattened as it ran immediately dorsal the flexor retinaculum, and the piso-hamate ligament became more distinct (Fig. 8). In the slice at the proximal part of the metacarpal bones, the flexor retinaculum disappeared, and the median nerve, which was further flattend, ran near the palm. A branch of the median nerve (recurrent nerve) was observed. Of the branches of the ulnar nerve, only the superficial branch was noted (Fig. 9).

Discussion

The carpal tunnel was formed by the carpal bones in its lateral and dorsal sides and by the flexor retinaculum with its proximal end on the line between the navicular and pisiform and its distal end on the line between the trapezium and the hook of the hamate on the palmar side.

In the carpal tunnel, a total of nine tendons, namely four each of the superficial and deep flexor tendons and the tendon of flexor pollicis longus, ran with the median nerve.

The flexor retinaculum increased its thickness as it approached the outlet of the carpal tunnel (maximum at the outlet) and gradually became distant from the palmar surface.

The median nerve ran immediately dorsal to the flexor retinaculum with no large artery in the carpal tunnel, and approached the palm again after it left the carpal tunnel.

The floor of the ulnar canal was composed of the flexor retinaculum and piso-hamate liga-

ment.

The roof was composed of thin volar carpal ligament and fibers of palmaris brevis.

The hook of hamate formed lateral wall and the pisiform with tendinous fibers of flexor carpi ulnaris the medial wall (SUNDERLAND)[9].

According to the authers' observation, the ulnar canal was located on the dorsal side of the flexor retinaculum at the inlet but soon penetrated the flexor retinaculum to its palmar side. The canal was formed medially by the pisiform and laterally by the hook of the hamate, but no tight connective tissue was observed on the palmar side except for the inlet portion.

In the ulnar canal, the ulnar nerve ran with the ulnar artery and vein, but no tendon was present.

The ulnar nerve ran on the lateral side of the pisiform and immediately bifurcated into superficial and deep branches, which were divided by a septum (piso-hamate ligament) (HAYES et al., 1969)[6].

Median nerve palsy due to compression at the wrist was documented early by PAGET (1853) and SCHULTZE (1890), and was shown by JONES (1895) to be caused by excessive motion of the wrist joint[4,7,8].

The role of the flexor retinaculum in this condition was first noted by MARIE and FOIX (1913) and was confirmed by surgical decompression by LEARMOUTH (1933)[6].

Median nerve compression is generally reported to be cured in more than 80% of the patients by opening of the carpal tunnel with release of the flexor retinaculum.

According to LANGLOH (1972), however, the flexor retinaculum partially remained in 62% (21/34) of the patients showing poor outcome, and MACDONALD (1978) reported that the most frequent complication was insufficient release of the flexor retinaculum (33%) followed by palmar branch injury (32%). Also POISEL (1974) observed that the recurrent branch of the median nerve penetrated the flexor retinaculum in 23% of the patients[1,5].

According to the authors' observation, the carpal tunnel departed from the palm from the inlet to the outlet, and the thickness of the flexor retinaculum increased and became maximum at the outlet.

These findings suggest that the flexor retinaculum must be released completely to its distal part under direct observation, for surgical treatment.

Detailed description of the anatomy of the ulnar canal by GUYON (1861) and the first report of neuropathy caused in this canal by HUNT (1908) were followed by numerous case reports[3].

It can be stressed that the ulnar canal differs from the carpal tunnel in that the roof is weeker, tendons and tendon sheaths are absent, and the ulnar nerve is accompanied by a major artery and vein.

Attention should be made to the direct chronic mechanical irritation or stimuli to the ulnar neurovascular bandle and to space occupying lesion such as a tumor or fracture fragments in the canal.

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和文抄録

手根管および尺骨管の形態的研究

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血管内にレジンを注入した成人上肢10肢を用い，5mm の間隔で連続切片を作製し，手関節近傍ことに手根管および尺骨管の形態の検索を行なった．

手根管はその入口部から出口部に至る間に徐々に手掌面より遠ざかり，また屈筋支帯は徐々に厚さを増し出口部で最大となっていた．

手根管症候群の手術療法に際しては屈筋支帯を直視下で充分に開放する必要があると考える．

尺骨管は骨性要素が少なく，入口部を除けば掌側は軟部組織でおおわれており，また腱も通過していないので，外部からの慢性の機械的刺激，腫瘍や骨折などの機械的狭窄因子が加わらない限り神経障害は生じにくいと考える．